Project: **1067**
Project title: **Fire-vegetation-climate interactions**
Principal investigator: **Gitta Lasslop**
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Simulations from the JSBACH-SPITFIRE model together with the simulations of six other fire-enabled vegetation models have been used to investigate the impact of fire on ecosystems in terms of tree cover and the carbon cycle on global scale.
Fire globally reduces the tree covered area and vegetation carbon storage by 10%. Regionally, the effects are much stronger, up to 20% for certain latitudinal bands, and 17% in savanna regions. Global fire effects on total carbon storage and carbon turnover times are lower with the effect on gross primary productivity (GPP) close to 0. We find the strongest impacts of fire in savanna regions. Climatic conditions in regions with the highest burned area differ from regions with highest absolute fire impact, which are characterized by higher precipitation. Our estimates of fire-induced vegetation change are lower than previous studies. We attribute these differences to different definitions of vegetation change and effects of anthropogenic land use, which were not considered in previous studies and decreases the impact of fire on tree cover. Accounting for fires significantly improves the spatial patterns of simulated tree cover, which demonstrates the need to represent fire in dynamic vegetation models. The model ensemble mean always performed better than individual models in comparisons with observational datasets, supporting the importance of model intercomparisons.

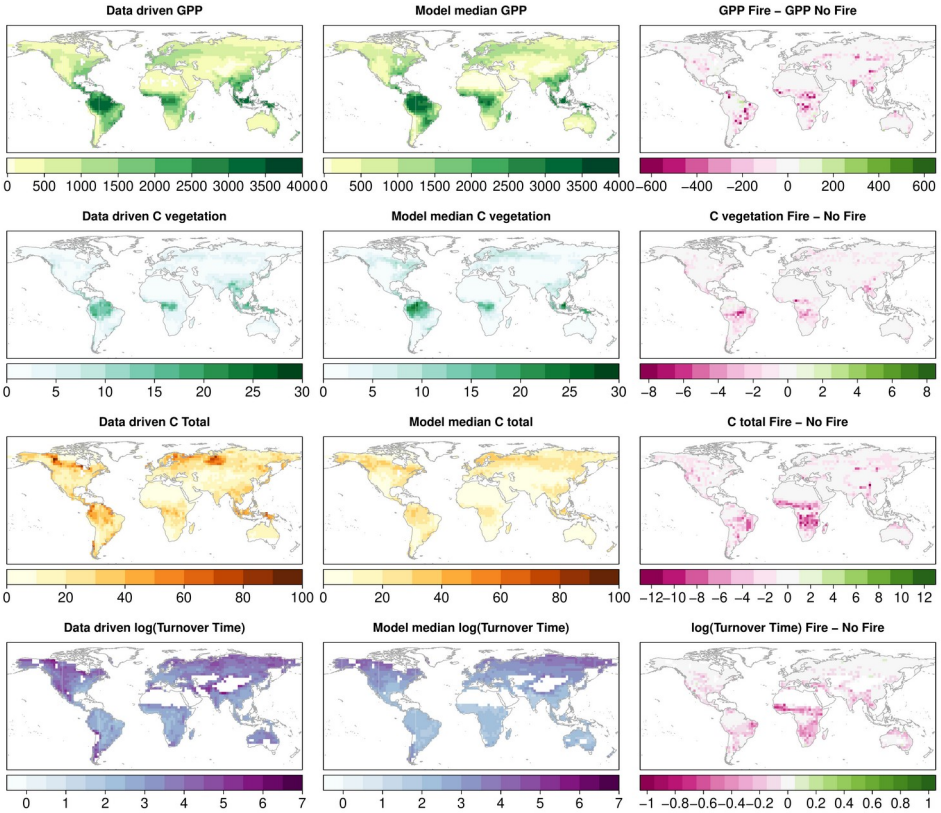

Figure 1: Observational datasets (first column), simulations including fire (second column), difference between simulations including fire and simulations where fire is switched off (third column) for gross primary productivity (GPP), vegetation carbon storage (C vegetation), total terrestrial carbon storage (C Total), and carbon turnover time defined as the ratio of GPP to C Total. The third column represents the quantification of the impact of fire on the different components of the carbon cycle.

Based upon comparisons between models and observations, process understanding and representation in models, we assessed a higher confidence in the fire impact on tree cover and vegetation carbon compared to GPP, total carbon storage and turnover times. We have higher confidence in the spatial patterns compared to the global totals of the simulated fire impact. As we used an ensemble of state-of-the-art fire models, including effects of land use and the ensemble

median or mean compares better to observational datasets than any individual model, we consider the presented results to be the current best estimate of global fire effects on ecosystems.

Information on the future fate of fire regimes is important for the planning of many areas, as fire is a direct threat to humans, causes respiratory diseases, impacts the ecosystem carbon storage and other ecosystem services, as well as biodiversity.
An analysis of simulations from the coupled model intercomparison project phase 6 (CMIP6) shows a significant increase in fire emissions in the extra-tropics, which is consistent across all Earth system models providing information on future fires (Figure 2). The signal in the tropics is rather mixed and trends are often not significant. These changes imply potentially strong impacts on the atmosphere.

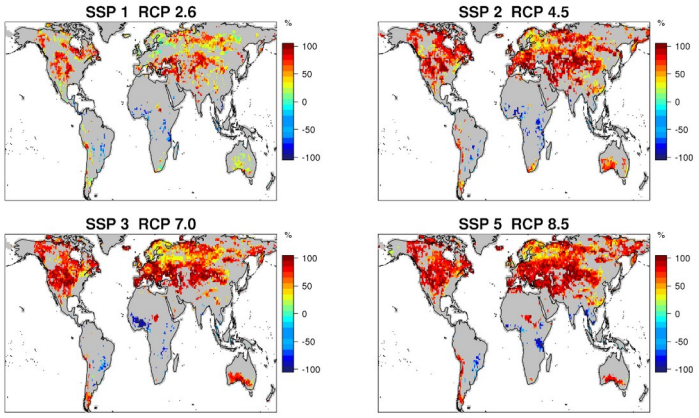

Figure 2: The graphs indicate in which grid cells all CMIP6 models agree on the sign of the mean change in emissions between present day (2001-2015) and the end of the 21st century (2086-2100). The colour indicates the percentage of the models with significant trends.

The Earth system models contributing to CMIP6 use biomass burning emission datasets as input to the atmosphere model. These are based on changes in human activities rather than climate change and show decreases in fire emissions for all scenarios (Figure 3). Not including the natural variation in fire emissions in these coupled simulations may impact the atmosphere significantly.

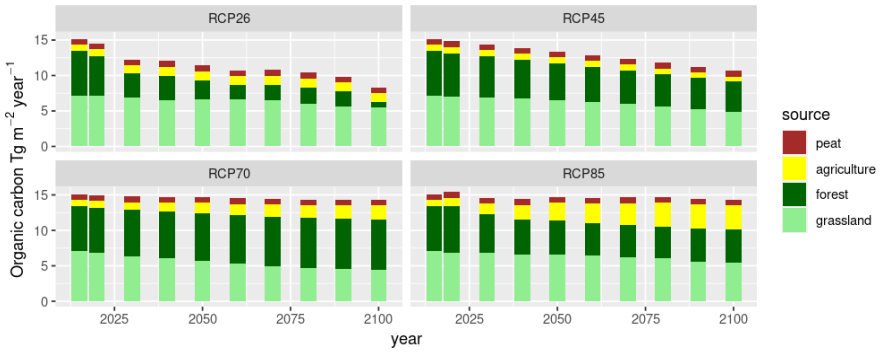

Figure 3: Biomass burning emissions of organic carbon for different climate scenarios used as inputs to Earth system models in CMIP6.

Publications:
Lasslop, G., Hantson, S., Harrison, S.P., Bachelet, D., Burton, C., Forkel, M., Forrest, M., Li, F., Melton, J.R., Yue, C., Archibald, S., Scheiter, S., Arneth, A., Hickler, T., Sitch, S., 2020. Global ecosystems and fire: multi-model assessment of fire-induced tree cover and carbon storage reduction. Glob. Chang. Biol. gcb.15160. https://doi.org/10.1111/gcb.15160